Capture and Phase Rotation for the Muon Collider

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Outline

1. The Baseline
2. The Capture System
3. Phase Rotation
4. Polarization

The current Scenario
(100 GeV Higgs Factory)

μ's/bunch:

In the Collider : 4×10^{12}
Losses in Acceleration (1/2) : 8×10^{12}
Losses in Cooling (1/2) : 16×10^{12}
Capture efficiency (1/2) : 32×10^{12}

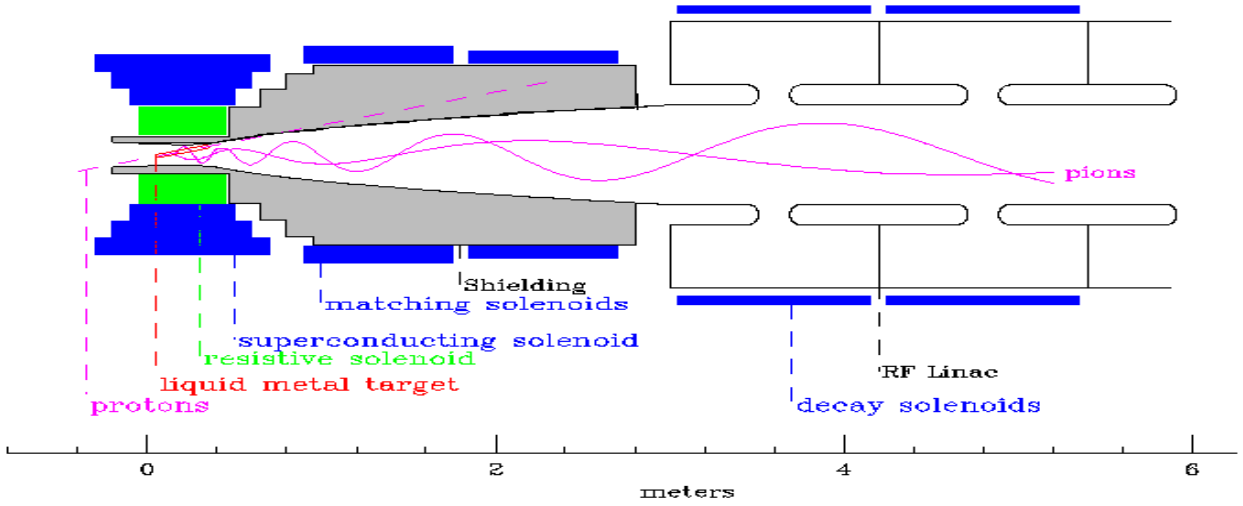
Proton beam:

Pions/Protons (0.6) : $5.4 \times 10^{13} \Rightarrow$ 140 kJ
(16 GeV/c protons and $0.05 < p_\pi < 0.80$ GeV/c)
Bunches/Pulse (2) : 280 kJ
15 Hz Operation : 4 MW

Power on the Target:

Per Pulse : 28 kW
15 Hz Operation : 400 kW

TARGET, CAPTURE & DECAY



- TARGET:Liquid Metal Jet
- CAPTURE:20 T Solenoid
- BEAM DUMP
- MATCHING
- DECAY & PHASE ROT:1.25 T

The Hybrid 20 T Solenoid

Strategy

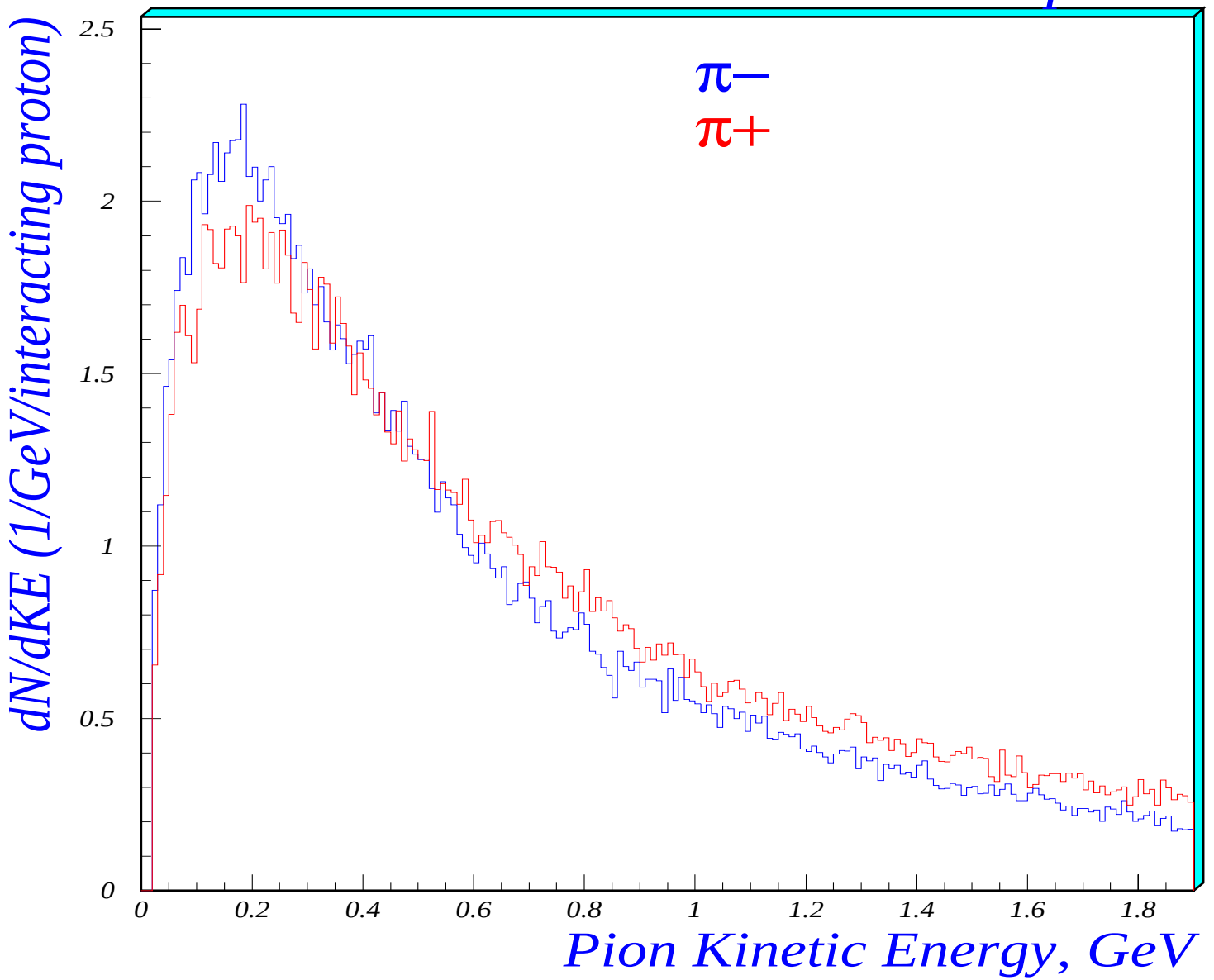
20 T + r=7.5cm $\Longrightarrow$ $P_t \leq$ 225 MeV/c

Solenoid Attributes

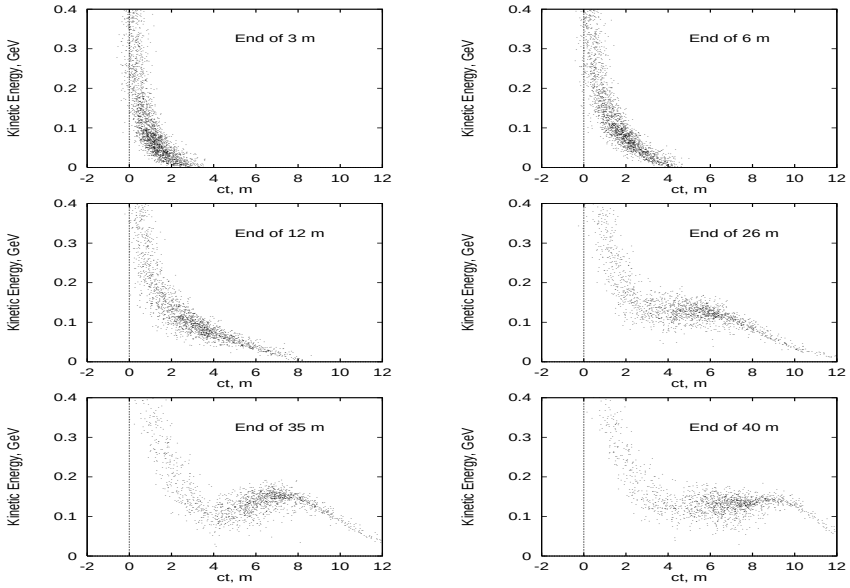
- Shielding
  - 15 cm ID – 24 cm OD
- Inner Coil
  - Resistive coil
  - 4 MW
  - 6 T
  - 24 cm ID – 60 cm OD
- Outer Coils
  - Superconducting
  - 14 T
  - 60 cm ID

Matching section

20 T $\rightarrow$ 1.25 T — warm bore 7.5cm $\rightarrow$ 30cm


Mars Meson Production - 16 GeV p + W
π−
π+
dN/dKE (1/GeV/interacting proton)
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Pion Kinetic Energy, GeV

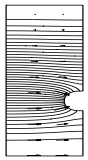
Phase Rotation Channel



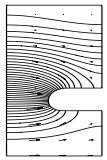
Phase Rotation Linac

RF frequency [MHz]	90	50	30
Cavity Length [cm]	120	120	120
Full Gap length [cm]	36	36	36
Cavity Radius [cm]	90	206	126
Beam Pipe Aperture [cm]	30	30	30
Q/1000 (from SFISH)	53.4	71.1	16.8
Ave Gradient [MV/m]	4.2	4.0	2.1
RF Peak Power [MW]	1.8	1.2	4.8
Ave Power (15Hz) [KW]	2.4	7.8	12.6
Stored Energy [J]	166	260	418
Linac Segment [m]	6	18	18
Total Power (15Hz) [KW]	12	118	190

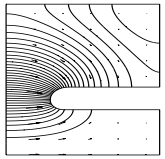
Low Frequency RF Cavities
For Muon Phase Rotation Channel



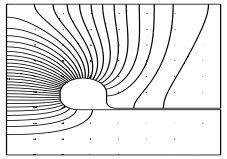
110 MHZ



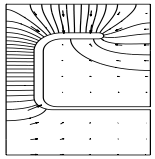
90 MHZ



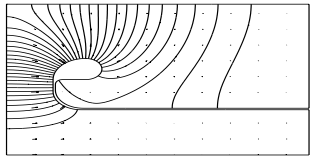
70 MHZ



50 MHZ



30 MHZ



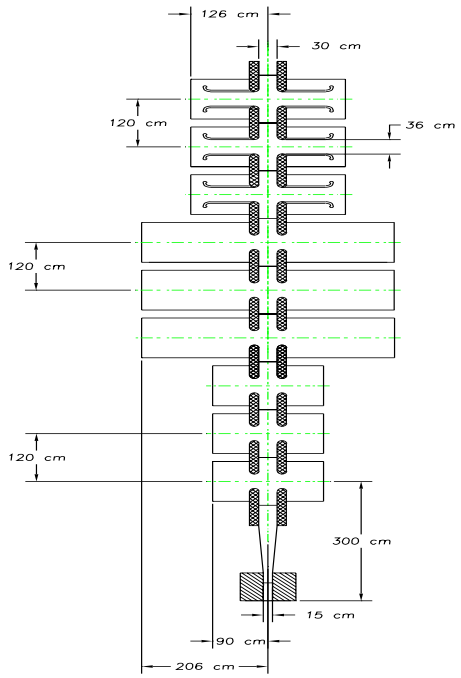
30 MHZ

Summary of Low Frequency Cavities

Gradients used in various models

	Parmela Kirk	MCMuon Palmer	ICOOL Fukui	MCMuon Palmer
Freq MHz		$< E >$ MV/m		
100	4.5			
90	4.2		4	
60	3.6	5		8
50	3.3		5	
45	3.3			7
30	2.1	4	4	5

Solenoids Inserts



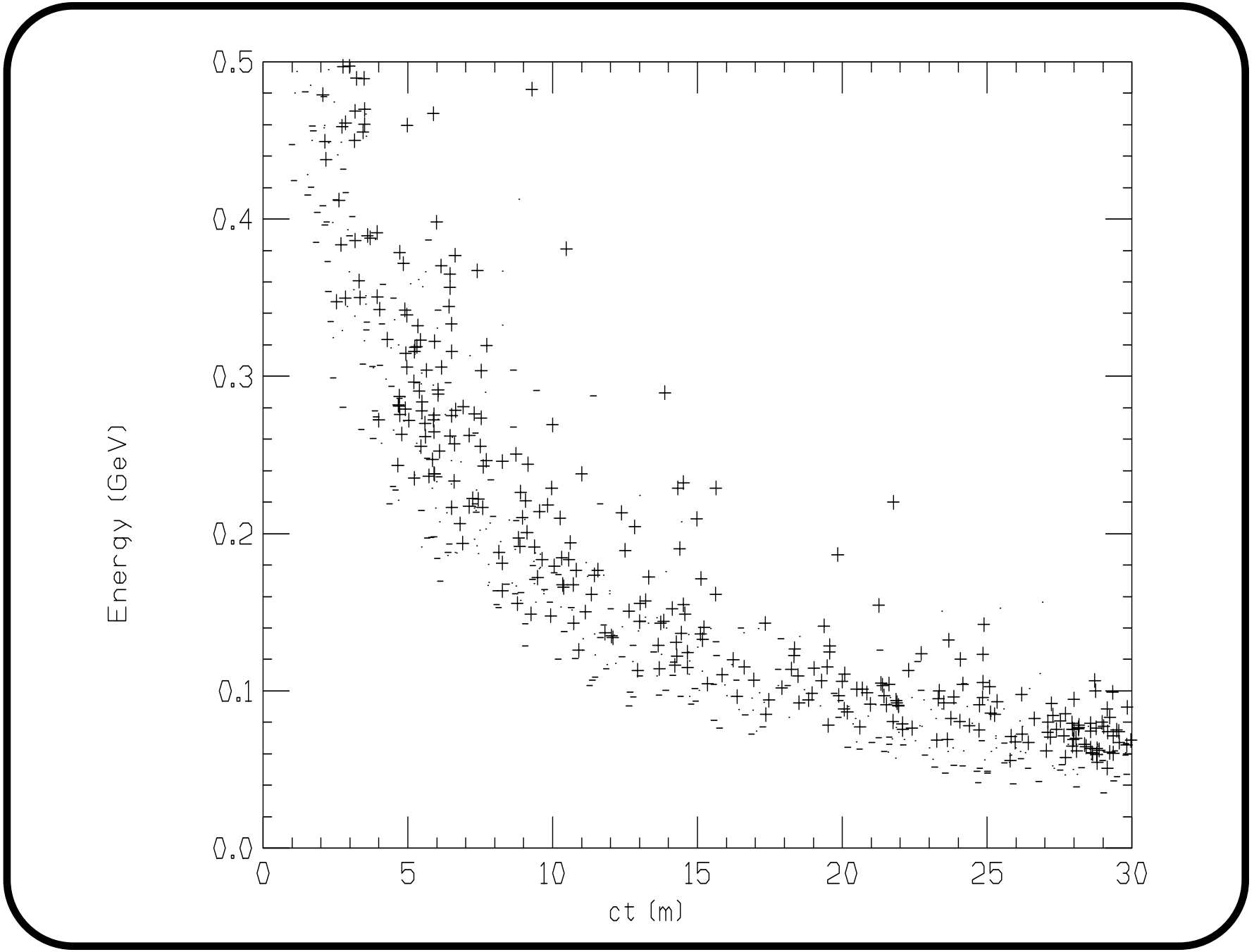
The Solenoid Channel

Solenoid outside of rf cavities

- Large Warm Bore 200 cm ID
- Restricted rf cavity radius 100 cm
- Modest B_z 1.25 T
- Large Beam Aperture 60 cm
- Uniform B_z

Solenoids inserted into rf cavities

- Reduced Warm Bore 30 cm ID
- High B_z 5 T
- Reduced Beam Aperture 30 cm
- Unrestricted rf cavity radius
- Non-uniform B_z (Stop bands)

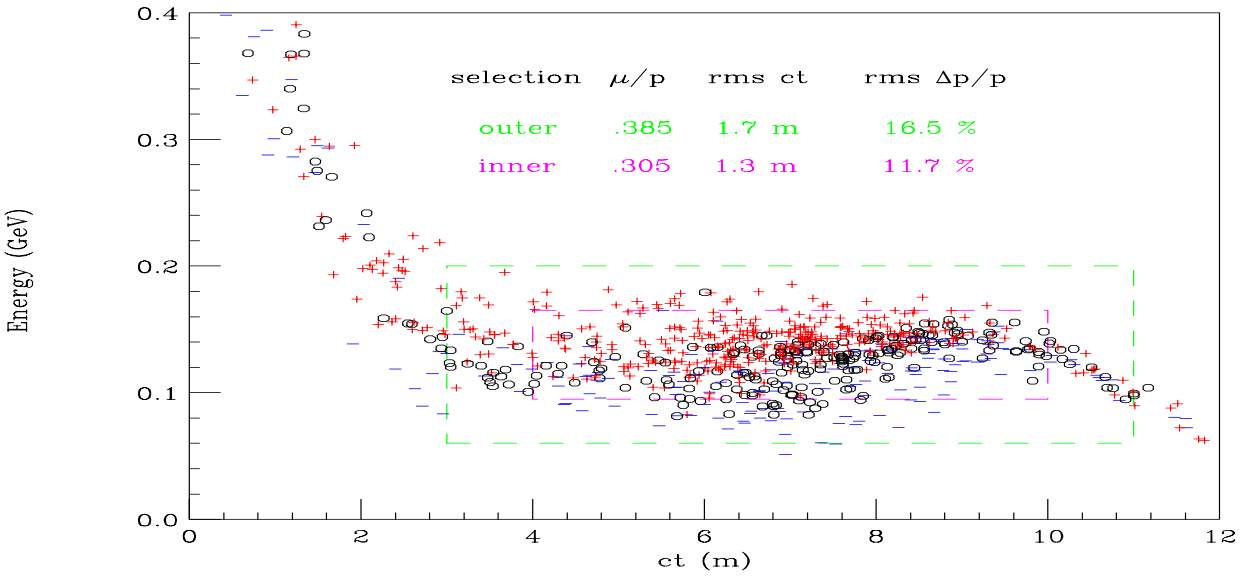

0.5
0.4
0.3
0.2
0.1
0.0
Energy (GeV)
0
5
10
15
20
25
30
ct (m)

R. Palmer

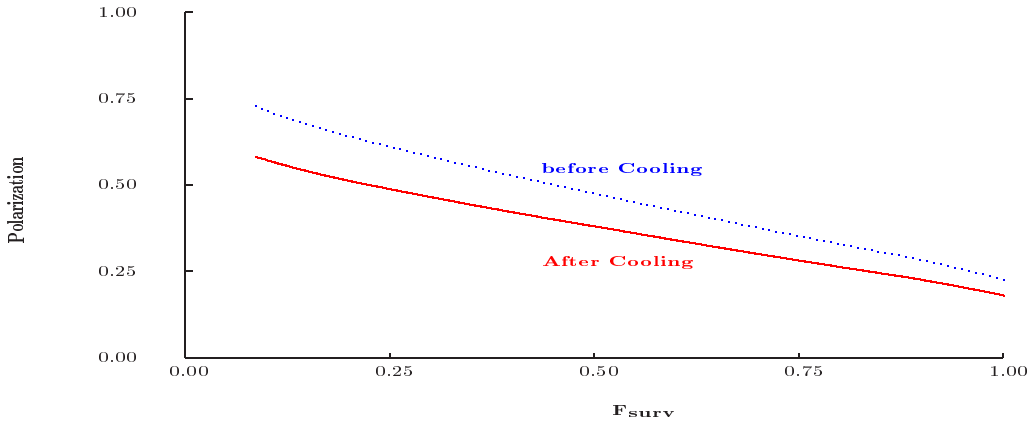
Muons at End of Phase Rotation

\+ muons with P $> \frac{1}{3}$

\- muons with P $< -\frac{1}{3}$



Polarization/Luminosity Trade off



Capture Issues

- Yield and spectra of low-energy pions
- Operation of a 20 T SC solenoid surrounding a $\approx$ 4 MW target
- Operation of rf cavity in high radiation environment
- High-gradient pulsed operation of low-frequency rf cavities